Prevention of Surface Fire Growth on Structural Composites

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Fiber-reinforced polymer composites are very attractive materials for a variety of infrastructure uses. For example, they are capable of replacing concrete and steel in such applications as bridge decks or even entire bridge structures and they are expected to offer significant life-cycle cost advantages in applications of this type. However, such large volume applications call for commodity polymer resins like polyester or vinyl ester whose flammability can be a substantial concern. The traditional way in which to deal with this flammability issue has been to incorporate bromine-based flame retardants into the resin. Another alternative is the use of phenolic resins; these strongly-charring polymers are inherently less flammable than the ester resins.

A confounding factor in the search for fire-safe composite materials for infrastructure applications such as bridges is the lack of any consensus on what constitutes a realistic fire threat to structures like these. The threats presumably range from vandalism to a full-fledged gasoline tanker fire. In any fire exposure there are two types of concerns for the composite. These materials lose their strength as soon as the resin either nears its glass transition temperature (thermoplastic resins) or begins to degrade (charring resins). Loss of local structural strength is thus the first concern. The second concern is that the fire may grow on the surface of the composite leading, in the worst case, to total structural collapse.

We have focussed on fire growth issues since control of this is of paramount importance. In previous work [1] we examined a 2.44m tall, 90° corner structure, challenging vinyl ester/glass composites with fires of varied sizes (23 and 38 cm square propane burners at the base of the corner, operated continuously at 30 to 150 kW). The results showed that this composite, which incorporated a bromine flame retardant, was still sufficiently flammable to yield rapid, full-height flame spread in response to a 150 kW initiating fire. (The unbrominated resin was substantially worse.) That study also included a promising first look at the ability of an intumescent coating to stop fire growth. It should be noted that upward fire growth on any material (the fastest, most threatening mode) is inherently assisted by increased heat release rate from the initiating source.

The current study is a follow-up, primarily on the issue of the ability of coatings to suppress fire growth. Here we have increased the height of the corner to 3.05m and focused on a single larger heat source -- a 53 cm square burner operated at a nominal power of 250 kW (see Fig. 1). This source is of a size achievable by vandals though requiring some effort; the corner configuration, with its radiative interchange, is more prone to fire growth than a flat structural element would be.

The materials examined included three types of polymer resins and five coatings; all composites were made with similar glass fiber reinforcement. Only specific combinations of materials were examined, not all possible variants.

Figure 2 shows an example of the measured heat release rate from the combined burner and sample, corrected for instrument response factors. The dashed line is the heat release rate from the burner itself. The sample shows an early peak and then a steady contribution of less than 100 kW. The coating itself, which has some controlled flammability, appears to be the source of most, if not all, of the sample's heat release rate. Flames reached the top of the corner, though rather weakly and diminished substantially after the HRR peak but weak lateral spread continued.

The results of this study are still being reduced but it is apparent that some commercially available coatings (mainly developed for other applications) are capable of stopping fire growth on unretarded vinyl ester composites, even under the fairly intense initiation/growth conditions imposed here. Interestingly, the best performance, in terms of minimal fire growth, was obtained with an uncoated phenolic composite. Heat penetration to the back of the composites was also examined but these results have not yet been reduced.

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References

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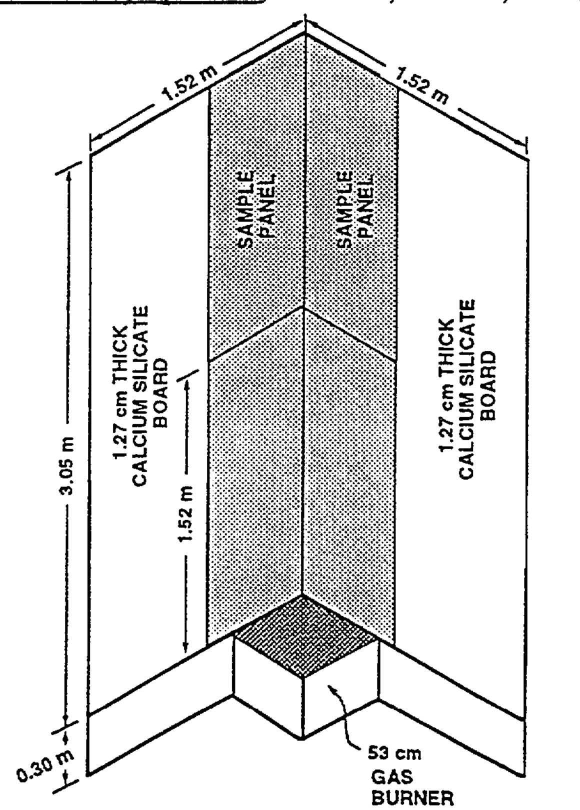

FIGURE 1. Schematic of Corner Burn Configuration (10 ft. Panels)

Figure 2
Corrected Rate of Heat Release
Vinyl Ester/ Glass with Coating A